Texas A & M University and U.S. Bureau of Reclamation
Hydrologic Modeling Inventory
Model Description Form

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Name of Model:

AGricultural Non-Point Source Pollution Models (AGNPS 98)

Model Type:

AGNPS 98 is a suite of continuous-simulation, pollutant loading & related water quality, surface-runoff computer models consisting of GEM (a daily weather generator), AnnAGNPS (the pollutant loading computer model), CONCEPTS (a dynamic channel morphological computer model), SNTEMP (a stream network water temperature computer model), SIDO (a daily sediment intrusion and dissolved oxygen status within a salmonid redd), and a set of salmonid models.

Model Objective(s) :

The purpose of AGNPS 98 is to offer the user a suite of models designed for: (1) pollutant loading (PL) predictions of water, sediment, & chemicals; (2) risk analyses of PL's anywhere within the watershed; (3) economic evaluation; and (4) restoration or preservation of aquatic habitat including salmonids.

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Model Structure or Mathematical Basis:

The models were developed for mixed land uses that specifically include agriculture and are designed for continuous simulation. The pollutant loading prediction model (AnnAGNPS) is designed for watersheds up to 1000 sq. mi. AGNPS 98 will accept input from the now obsolete, single-event version of AGNPS 3.65 to 5.0 and convert it to input for AnnAGNPS which will also handle a single-event.

GEM—a probabilistic model—and its subsidiary weather-related computer programs, is a synthetic climate generator. It predicts a stochastic set of daily weather parameters of any number of years that can be used to generate the climate input for AnnAGNPS.

AnnAGNPS—a mixed set of lumped sum, distributed processing, deterministic, and probabilistic models—includes a set of landscape processes (daily mass balancing of precipitation, agricultural management for tillage & chemical operations, point sources, and, when surface runoff occurs, sheet & rill erosion, gully erosion, and feedlots) and a stream routing (stream routing of the surface runoff of water, sediment, & chemicals). The hydrologic component consists of precipitation (rain, snow, or irrigation), infiltration based upon the SCS curve number, daily soil moisture evapotranspiration & percolation, and surface runoff. Sediment yield to the stream system is based upon sheet & rill erosion (RUSLE), gullies, and bed & bank erosion. The stream routing for sediment yield uses a modified Einstein sediment deposition equation. The Einstein equation was modified by introducing the Bagnold equation as a sediment transport capacity below which there is no deposition and above which there is only potential deposition for the difference. The instream chemical processes include equilibration and decay. The model is capable of determining where any pollutant loading at any point within the watershed originated.

CONCEPTS—a one-dimensional, hydrodynamic, distributed processing model—is a distributed, continuous, long-term channel evolution and water quality model for use in ungaged watershed systems. The basic components are channel hydraulics, morphology, and transport of sediments and contaminants. CONCEPTS is designed to simulate unsteady, one-dimensional flow, graded-sediment transport, bank erosion processes, and pollutant transport in watershed channels, incorporating instream hydraulic structures and non-structural remediation measures. Stage-discharge relationships are computed using diffusion wave technology providing a computationally efficient and accurate model. Channel evolution is computed by tracking bed changes and channel widening. Bank erosion accounts for basal scour and mass wasting of unstable cohesive banks. CONCEPTS simulates transport of sediments, both in suspension and on the bed, and selectively by size classes. Channel boundary roughness and bank stability affected by riparian vegetation are included in CONCEPTS. Transport and fate of conservative and reacting contaminants, and effects of water temperature are being added to the model.

SNTEMP is a mechanistic, one-dimensional heat transport model that predicts the daily mean and maximum water temperatures as a function of stream distance and environmental heat flux. Net heat flux is calculated as the sum of heat to or from long-wave atmospheric radiation, direct short-wave solar radiation, convection, conduction, evaporation, streamside vegetation (shading), streambed fluid friction, and the water's back radiation. The heat flux model includes the incorporation of groundwater influx. The heat transport model is based on the dynamic temperature-steady flow equation and assumes that all input data, including meteorological and hydrological variables, can be represented by 24-hour averages.

SIDO—a two-dimensional, hydrodynamic, distributed processing model—was formulated to quantify the cause and effect relationship between the survival of anadromous salmon species and the quality of aquatic habitat supported by gravel-bed streams. SIDO is also a deterministic model, which operates on two coupled stream and redd domains. First, the flow of oxygen-saturated and sediment-laden water over a gravel stream bed is simulated in the one-dimensional stream domain. Second, the intrusion of sediment fines and movement of oxygenated water through the gravel substrate is simulated in the two-dimensional redd domain. Simulated substrate processes include deposition of fines in the gravel interstices, and oxygen consumption by respiration of salmonid embryos and fry and by sediment organic matter. The model is designed to handle any mixture of fine sediment matrix and gravel framework.

The remaining set of salmonid models—all emperical models—are for: (1) determining the percent of fry to emerge from the redd; (2) completing an analysis of the total life cycle for salmonids; and (3) an economic procedure for the net value of the commercial & recreational catch of salmonids in the Pacific Northwest related to return spawners.

Model Parameters:

AGNPS 98 uses three basic GIS data layers: (1) digital elevation model to determine watershed & subwatershed boundaries and the stream network; (2) digitized soils map and its associated NASIS database; and (3) digitized landuse map and the attribute database that includes all significant agriculture management data such as tillage operations, fertilizer & pesticide management, irrigation schedules, rotations, etc.

Spatial Scale Employed in the Model:

AGNPS 98 is decomposed into a network of subwatersheds (cells) that are connected hydrologically by stream reaches.

Temporal Scale Employed in the Model:

AGNPS 98 is a daily continuous-simulation model but may synthetically disaggregates time into shorter periods for some of the subcomponents.

Input Data Requirements:

Climate data: longitude & latitude of a reference point within the watershed.
Watershed data: digitized elevation, soils, and landuse maps with their respective attribute databases.
Stream cross-section data by reach: bankfull depth, bankfull top width, and valley top width but these can be mostly satisfied by using hydraulic geometry relationships.

Computer Requirements:

The input/output computer programs have been written mostly in Visual Basic with some components written in ANSI standard Fortran 90. All science-based computer programs (GEM, AnnAGNPS, CONCEPTS, SNTEMP, & SIDO) have been written in ANSI standard Fortran 90, therefore the code is portable to any computer system that supports ANSI standard Fortran 90. Some models are available as Excel spreadsheet solutions (some of the spinoffs from the water temperature, salmonid total life stages, and salmonid economics models).

Model Output:

AnnAGNPS predicts, under user control, pollutant loadings (water, sediment, & chemicals) anywhere in the watershed for each storm event and by point of origin of specified pollutant load. The user can specify whether water, sediment by particle size and type of erosion, chemicals (nitrogen, phosphorous, organic carbon, or any number of pesticides) are output and where they may have originated.

CONCEPTS predicts aggradation & degradation of the stream bed, bank failure & mass wasting, and sediment yield over time.

SNTEMP predicts the daily average, minimum, & maximum water temperatures anywhere within the stream network.

SIDO predicts the daily sediment & dissolved oxygen status within a salmonid redd.

The salmonid total life stages predicts the maximum number of commercial & recreation salmonid catch that would be permissible and still maintain the necessary number of return spawners while accounting for all the various mortalities a run throughout its life-cycle.

Parameter Estimation / Model Calibration:

AGNPS 98 can have parameters estimated by the user or have AGNPS 98 use default values.

Model Testing and Verification:

AnnAGNPS is an extension of the earlier single-event AGNPS version 3.65-5.0 pollutant loading model using more up-to-date readily available technology such as RUSLE.

CONCEPTS is a recently developed research model that has been tested within Mississippi watersheds.

SNTEMP has been extensively tested using watersheds other than those used for the originally development, is supported by the USGS with many spinoffs for specialty tasks.

SIDO was developed, verified, validated, and field tested in a watershed in the Pacific Northwest (Tucannon River) and has been used in other watersheds by other agencies since then with minor modifications.

The remaining salmonid models were developed and used for the Tucannon River. They were based upon field & laboratory data collected by recognized researchers for salmonids. They have been subsequently used by others in the Pacific Northwest & West.

Model Sensitivity:

AnnAGNPS: Depending upon the hydro-geomorphic region of the watershed, certain parameters & components may become more or less sensitive, but climate variability and landuse, particularly agriculture management, always seem to have a significant effect on the pollutant loadings.

CONCEPTS: Aggradation/degradation of the bed and the undercutting of the banks are sensitive as to whether the sediment yield at the upstream end of the reach is supply or transport limited. The time it would take for contaminated sediments to be removed from the bed is a function of the total mass present, its sediment transport capacity, and the amount of incoming sediment. The dynamics of bank failure & mass wasting also is a function of the soil properties.

SNTEMP: While the water temperature is sensitive to the weather parameters, particularly the air temperature, the potentially controllable parameters, listed in order of probable importance, are: (1) riparian vegetation; (2) irrigation return flows; (3) stream withdrawls, and (4) stream channel widths.

SIDO: fine sediment concentrations and their flow duration are the single biggest parameters. Water temperature during the spawning season may also be a factor, but not often.

The fry emergence model is sensitive to the dissolved oxygen & water temperature status during the incubation period.

The total life stages is sensitive to: (1) number of return spawners; (2) carrying capacity of the rearing habitat; (3) predators within the rearing habitat; (4) upstream & downstream migration mortality, especially to manmade obstacles such as dams; (5) predators in the ocean; and (6) fisheries management for commercial, recreational, and tribal catch.

Model Reliability:

AGNPS 98's components have been used by many agencies, universities, and consultants and is actively supported by the Agricultural Research Service, National Sedimentation Laboratory in Oxford Mississippi.

Model Application / Case Studies:

AGNPS 98 has been applied to the analyses and planning of a wide geographical area of projects involving water quality, fisheries restoration, aquatic assessments, and the re-licensing of hydro-electric dams.

Documentation:

User documentation is available at the AGNPS 98 Web site at: "http://www.sedlab.olemiss.edu/AGNPS98.html". Here the user can find topic abstracts, reference files, technical documentation, executable modules, verification data sets, fact sheets, and individual personal contact information for either technical or software support.

Other Comments:

The AGNPS 98 project team periodically offers a one-week workshop for AGNPS 98 that can be tailored for specific applications of the suite of models.